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W Lyræ.

This variable seems to have attained its maximum luster some weeks before the 9th of March, for which it was predicted in the *Companion to the Observatory*.

1902. Jan. 11. About half a mag. brighter than π , which is 8.1 mag.
 Jan. 20. Equal to π ; brighter than α of 8.6 mag.
 Jan. 27. Ditto. Morning very clear. W seems yellowish in color.
 Feb. 12. Rather brighter than π —what might be classed as two tenths. Distinctly brighter than α .
 Feb. 22. Equal to π .
 Mar. 13. Dimmer than α , but brighter than g of 10th mag., and equal to p of 9.4 mag.

R Ursæ Majoris.

The maxima of this star vary from 6 to 8.2 magnitude. The recent maximum was due on February 8th.

1902. Jan. 31. Equal to h , but not to g , which seems slightly brighter. Both comparison-stars are classed as of 8th mag.
 Feb. 2. Ditto.
 Mar. 12. Ditto.
 Mar. 14. Decreased to π of 9th mag.
 Mar. 24. It is of about 10.3 mag.

L² Puppis.

The maximum of this star was due February 28th.

1902. Jan. 31. Brighter than 4th mag., as compared with *Sigma Puppis* of 3.4 and L^1 of 5th mag.
 Feb. 12. } Ditto.
 Mar. 2, 9. }
 Mar. 14. Slightly brighter than b *Puppis*. Classed as of 4.8 mag

SAN FRANCISCO, March 31, 1902.

KAPTEYN'S CONTRIBUTIONS TO OUR KNOWLEDGE OF THE STARS.

By J. D. GALLOWAY.

In commenting on the award of the gold medal of the Royal Astronomical Society to Professor J. C. KAPTEYN for his work in connection with the Cape Photographic *Durchmusterung* and his researches on stellar distribution and parallax, Dr. GLAISHER, the president of the society, gave a brief history of

this great photographic catalogue, and referred to some of KAPTEYN's other contributions to stellar cosmography.

The idea of making a photographic star-map was suggested to GILL when experimenting with an ordinary camera in photographing the great comet of 1882. The work for the catalogue was done with a Dallmeyer rapid rectilinear lens of six inches aperture and fifty-four inches focus. Another lens was tried for a time, but found unsatisfactory, and all plates taken with it were discarded; so that the finished work is the product of one lens. Part of the expense was borne by the Government Grant Fund of the Royal Society, part by the Dutch Government, and part by several Dutch institutions. One reason for the withdrawal of the Royal Society from the work was the commencement, in 1887, of the preparation of the International Astrographic Chart. It was thought by some that this would supersede the work of GILL and KAPTEYN; but the belief of Dr. GILL was that there was an immediate use for his work, so it was pressed to a conclusion.

KAPTEYN offered his services to GILL in 1885, stating that he believed he had "enthusiasm for the matter equal to six or seven years of such work." He did not overestimate his enthusiasm, which was to sustain him not only for six or seven years, but for nearly thirteen. KAPTEYN's proposal was that he be allowed to measure the plates taken at the Cape and to tabulate the results. The actual photographing of plates at the Cape began in April, 1885, and was completed at the end of 1890.

The principal object which GILL had in view may be briefly described as the extension of the Bonn *Durchmusterung* to the south pole. To determine the exposure necessary for this purpose, an area in the Bonn *Durchmusterung* was selected and photographed. The negative was then compared star by star with ARGELANDER's chart, and the duration of the trial exposures was gradually increased till it was certain that every star in the selected part of the chart was shown as a measurable disc on the plate photographed from the sky. It may be mentioned that when the negative from the sky showed nearly the whole of ARGELANDER's stars, it also showed a great many more, as the Bonn *Durchmusterung* professes to complete only as far as stars of the 9.2 magnitude. Every area was photo-

graphed on two different nights, in order to avoid the possibility of a speck on the plate being mistaken for a star.

KAPTEYN's work was done at Groningen, Holland, and consisted in the measurements of the stars on the plates, their reductions, and the forming of the catalogue. All the measurements for the catalogue were made by an instrument designed by KAPTEYN for the purpose. The principle of this instrument, the object of which was to measure spherical coördinates from the plate, occurred to him very soon after he had received the first plates. It depends upon the obvious fact that by placing a plate at the proper distance (that is, at the focal distance of the photographic telescope), with the film farthest from the eye, it is possible to cover the stars in the sky with their corresponding images. If, therefore, we substitute for the eye an instrument by which spherical coördinates can be measured in the sky, we can measure these coördinates as well on the plate. Various refinements were used. The work was done in a darkened room by two observers and a clerk. Two plates covering the same region were fixed in the holder, and by adjustment were so placed that the image of a star on one plate nearly covered the image of the same star on the other plate. True stars then appeared double, while accidental specks appeared single, and could at once be distinguished.

Each plate was observed twice, and as soon as the second observation was made the results were compared and discrepancies examined. The second observations and examinations were invariably made by KAPTEYN.

The diameters of the images of the stars were estimated to 2" of arc, and from these diameters the magnitudes of the stars were determined by an empirical formula.

The work is published in three volumes, bearing dates of 1896, 1897, and 1900. It includes all stars down to about 9.5 magnitude from -18° to the south pole. The number of stars included is 454,857. The catalogues of ARGELANDER and SCHÖNFELD together contain 431,760 stars for the rest of the sky, the average number per square degree being for the Cape, Argelander and Schönfeld catalogues 32.66, 15.19, and 18.21, respectively, so that the star-density of the Cape catalogue is more than double that of ARGELANDER'S.

As compared with the catalogue of SCHÖNFELD, the star

density shown by the Cape catalogue varies widely, some regions containing three times the number of stars given by SCHÖNFELD in the same area, while in some regions the latter's catalogue was the richer, containing almost double the number shown on the plates. KAPTEYN also found that, corresponding to these variations in the star-brightness, equal diameters on the plates were produced by stars of unequal brightness in different parts of the sky. THOME suggested that this might be due to a tendency on the part of a visual observer to overlook faint stars in a rich field; but KAPTEYN considers any such explanation quite inadequate, and he concludes that the difference between the visual and the photographic magnitudes is largely due to the positions of the stars with regard to the Milky Way, and that, even if we take into account only stars of the same spectral type, those in the Milky Way are in general bluer than the stars in other regions of the sky.

In 1889 KAPTEYN proposed a comprehensive method of determining stellar parallax, having been engaged in that work when he made his proposal to GILL in 1885. His plan was to expose the plates for the astrographic catalogue at three successive epochs of maximum parallactic displacement, the plates being carefully preserved in the intervals of six months, and developed after the third exposure. The plates would then furnish, in addition to the position of the stars, a first determination of their parallaxes. The proposal was not adopted for the great catalogue, but Professor DONNER obtained a series of plates at Helsingfors which were measured by KAPTEYN and the approximate determinations of the parallaxes of 246 stars were made.

Since the direct determination of stellar parallax has not given results on anything like the scale required for the purpose of judging of the relative distances of the stars, we are compelled to resort for data on this point to the parallactic displacement caused by the motion of the solar system in space. This parallactic motion, however, cannot be separated from the real proper motion for the individual stars, but there is every reason to think that the real proper motion shows but little preference for determinate directions, and it may therefore be assumed that, in the mean results obtained from small groups of stars, these real proper motions will destroy each other, leaving only

that part due to solar motion. It is this parallactic displacement that gives the most reliable measure of the mean distances of stars. KAPTEYN has undertaken the resolution of the proper motions of 2,357 stars into components in the apical direction (that is, the direction of the Sun's movement in space), and normal thereto. These stars are in the Draper catalogue of spectra, and are also included in the Bradley-Auwers catalogue of Right Ascensions and Declinations. The stars were taken from the Draper catalogue, because KAPTEYN had decided to divide them into groups according to their spectral type, and to consider the groups separately. This division has shown that stars with small proper motions belong generally to the first type, and those with large proper motions to the second, to which type our own Sun belongs. It may be that the stars of the second type are moving faster than those of the first, but it seems more probable that they are less distant. This gives some support to GOULD'S suggestion that the Sun is a member of a star-cluster.

Other important papers of KAPTEYN refer to the distribution of cosmical velocities, the distribution of stars in space, the statistical relations between parallax, proper motion, and magnitude, and upon the luminosity of stars. He has deduced the position of the solar apex by a new method, in which the apex is so chosen that the sum of the proper motions resolved in the direction of the Sun's apex is a maximum, or that the sum of the motions perpendicular to this direction is zero. The resulting apex is $\alpha = 273^{\circ}.6$, $\delta = 29^{\circ}.5$ as deduced from 2,640 Bradley stars and 699 Porter stars. The discrepancy from PORTER'S results (obtained by KAPTEYN'S method), $\alpha = 280^{\circ}.5$, $\delta = 49^{\circ}.3$, and from CAMPBELL'S result, $\alpha = 277^{\circ}.5$, $\delta = 20^{\circ}.0$, derived from spectroscopic determinations of 280 velocities in the line of sight, only shows what might have been expected—that considerable groups of stars in different parts of the sky are affected by common drift which is quite distinct from parallactic motion.

As showing the estimation in which KAPTEYN'S work is held, the following is added from NEWCOMB, when writing of the Cape *Durchmusterung*: "This work of KAPTEYN offers a remarkable example of the spirit which animates the born investigator of the heavens. . . . The years of toil devoted to

it were, as the writer understands, expended without other compensation than the consciousness of making a noble contribution to knowledge, and the appreciation of his fellow astronomers of this and future generations."

PLANETARY PHENOMENA FOR JULY AND AUGUST, 1902.

BY MALCOLM MCNEILL.

JULY.

The Earth is in aphelion July 4th, 5 A. M. Pacific Time.

Mercury is a morning star, having passed inferior conjunction on June 23d. It reaches greatest west elongation on July 15th, and is well on toward superior conjunction by the end of the month. The conditions for visibility are not very good; but after the first week of the month the planet rises an hour or more before sunrise, and there is a possibility of seeing it in the morning twilight if the air is very clear.

Venus is the chief morning star, and throughout the month rises about two and one-half hours before the Sun. It moves about 35° eastward during the month from a position between the *Pleiades* and *Hyades* in *Taurus* to the middle of the constellation *Gemini*, west and south of *Castor* and *Pollux*. Its distance from the Sun diminishes about 5° .

Mars is also in the morning sky, but has not begun to brighten up very much. It moves about 20° eastward from the eastern part of *Taurus* into *Gemini*, and toward the close of the month is near *Venus*, a little to the north of the latter.

Jupiter will, at the end of the month, rise a little after sunset, and is therefore in fair position for late evening observation. It is in the eastern part of the constellation *Capricorn*, and is moving westward, the motion being about 3° during the month, and on a line a little south of the line of motion during the spring months.

Saturn comes to opposition with the Sun on July 17th, and is therefore above the horizon practically the entire night, during the month. It is in the western part of the constellation